SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 10. IRRIGATION METHOD DESIGN

Contents

		Page
Chapter 10-A.	Permanent/Solid-Set Sprinkler Irrigation System -------	10-A-1
	General ----------	10-A-1
	Design Criteria ----------	10-A-1
	Example Problem ----------	10-A-1
	Layout Considerations ----------	10-A-9
	Construction Requirements ----------	10-A-10
Chapter 10-B.	Traveling Gun Sprinkler Irrigation System ----------	10-B-1
	General ----------	10-B-1
	Design Criteria ----------	10-B-1
	Example Problem ----------	10-B-1
	Layout Considerations ----------	10-B-6
	Construction Requirements ----------	10-B-6
Chapter 10-C.	Center Pivot Irrigation Systems ----------	10-C-1
	General ----------	10-C-1
	Design Criteria ----------	10-C-1
	Formula Used in Design and Evaluating Center Pivot Irrigation Systems ----------	10-C-1
	Example Problem ----------	10-C-2
	Construction Requirements ----------	10-C-6
	Layout Considerations ----------	10-C-6
	Procedure for Determining Gross Application of Center Pivot Sprinkler ----------	10-C-7
Chapter 10-D.	Trickle Irrigation System ----------	10-D-1
	General ----------	10-D-1
	Design Criteria ----------	10-D-1
	Example Problem ----------	10-D-1
	Material and Construction Requirements ----------	10-D-4

Tables

		Page
Table 10-A-1	Typical Sprinkler Manufacturer's Data ----------	10-A-9
Table 10-B-1	Recommended Towpath Spacings For Traveling Sprinklers ----------	10-B-7
Table 10-B-2	Guide for Flexible Irrigation Hose Selection ----------	10-B-7

Exhibits

		Page
Exhibit 10-A-1	Irrigation Data Sheet - Permanent/Solid-Set Sprinkler Irrigation System (Example Problem)	10-A-11
Exhibit 10-B-1	Irrigation Data Sheet - Traveling Gun Irrigation System (Example Problem)	10-B-8
Exhibit 10-C-1	Irrigation Data Sheet - Center Pivot Irrigation System (Example Problem)	10-C-10
Exhibit 10-D-1	Irrigation Data Sheet Drip Irrigation System (Example Problem)	10-D-5

CHAPTER 10-A. PERMANENT/SOLID-SET SPRINKLER IRRIGATION SYSTEM

GENERAL

The example problem in this chapter is intended to illustrate the procedure to follow in the design of permanent and solid-set irrigation systems. It is understood that one example cannot illustrate all design situations or alternatives to consider when designing a permanent or a solid-set irrigation system.

DESIGN CRITERIA

Design criteria for permanent and solid-set irrigation systems is contained in the Technical Guide, Irrigation System, Sprinkler, Code 442, for South Carolina. All sprinkler irrigation systems must be designed in accordance with the criteria contained in Code 442.

EXAMPLE PROBLEM

The following example problem is intended to cover the basic design steps to follow in the design of permanent/solid-set sprinkler irrigation systems. A standard form (Exhibit 10-A-1) is used which is a useful tool in designing and recording data.

Given

1. Location: Aiken, South Carolina.
2. Field Shape: 1320 feet east to west by 660 feet north to south (20 acres).
3. Soil: Dothan loamy sand on 0 to 5 percent slopes.
4. Crop: Small vegetables - Recommended design use rate of 0.18 in./day.
5. Row direction and spacing: Rows run north to south 30 inches apart.
6. Plant spacing along row: Varies.
7. Well information: 12-inch well without pump. Power unit planned is electric, 3 phase. Static water level is at 75 feet below ground surface. At a 400 GPM pumping rate, water level is at 125 feet. Pump centerline is at 140 feet.
8. Owner would like to operate system about 8 hours per day using manual shut off valves.
9. All pipe to be buried a minumum of 30 in. below the ground surface.

Solution:

The item numbers mentioned in the step by step solution refer to the items on the "Irrigation Data Sheet" in Exhibit 10-A-1.

Step 1. Complete Items 1-4. These items provide an inventory of pertinent data at the site.

Step 2. Complete Item 5. Make a drawing to scale of the field locating buildings, trees, well and other features.

Step 3. Complete Item 6, except for acreage to be grown which will be discussed later. Guidance in selecting the moisture extraction root depths (soils moisture control zone) and the design peak use rate are to be taken from this guide, Tables 3-1 and 4-1 respectively. The weighted AWC is computed using data from item 1.

Step 4. Complete the following parts of Item 7.

a. Available water capacity (AWC) within the water control (root) zone is the product of the root zone moisture extraction depth (12 in.) times the weighted moisture holding capacity of the soil (0.08 in./in.). AWC = (12 in.)(0.08 in./in.) = 0.96 in.

b. The percent depletion recommended prior to irrigation is 40% for truck crops as set forth in the Chapter 11 of this guide.

c. The maximum net water allowed per irrigation (in.) is the product of the percent depletion allowed prior to irrigation times the water available within the root zone. The maximum net water allowed per irrigation in this example is = (0.40) (0.96 in.) = 0.38" in.

d. The net water to be applied must be less than or equal to the maximum allowed. Use the maximum for this example - 0.38".

e. Maximum application rate from table 2-6 for loamy sand, 0.38" water applied, and 4 percent predominate maximum slope = (No limit).

f. The system efficiency is assumed to be 70 percent.

g. The gross water applied per irrigation (in.) is found by dividing the net water applied per irrigation by the system efficiency. Gross water applied = 0.38 in. ÷ 0.70 = 0.54 in.

h. The peak irrigation interval (days) is determined by dividing the net water applied per irrigation by the crop peak consumptive use rate. Peak irrigation interval = 0.38 in. ÷ 0.18 in./day = 2.1 days.

i. Normally, the irrigation period in days to be used in the formula for determining Q_R is the irrigation interval (2.1 days) determined above. However, in this example the field was broken up into four irrigation units of 5 acres each which resulted in two units being irrigated each day (10ac/day). Therefore, one (1) day was entered in each column for the irrigation period and 5 acres per irrigation unit in Item 6. The advantages of dividing the field into four units is that a smaller pump can be used and a small well capacity is required.

h. Four hours operating per day per plot was requested by the owner; however, do not enter this value yet.

Step 5. Tentatively determine the quantity of water required Q_R for each irrigation unit. Use the formula:

$$Q_R = \frac{453\ Ad}{F\ H}$$

Where Q_R = minimum required discharge capacity in gallons per minute

A = acreage of the design area

d = gross depth of application in inches

F = number of days allowed for completion of one irrigation

H = number of actual operating hours per day

$$Q_R = \frac{453 \times 5 \text{ acres} \times 0.54 \text{ in. gross application}}{4 \text{ hrs operating per day} \times 1 \text{ day per irrigation}}$$

Q_R = 306 gpm

Note that the Q_R should not exceed the well capacity. In situations where the well capacity is exceeded then the irrigation unit acreage would need to be decreased or the operating hours per day increased or a well of higher capacity would have to be installed.

Step 6. Select a sprinkler spacing that is compatible with farming operations. Some alternatives would be 40 ft by 60 ft or 60 ft by 60 ft. The 40 ft by 60 ft in a rectangular pattern was tentatively selected.

Step 7. Check the sprinkler spacing requirement in the Technical Guide Code 442. Irrigation will be done under average wind conditions (less than 5 mi/hr). The sprinkler spacing should be no greater than 50% of the wetted diameter and the lateral spacing should be no greater than 65% of the wetted diameter.

Step 8. Select a sprinkler. There are two requirements for which the sprinkler selection is to be based: (1) the wetted diameter must be at least 92.3 feet. This is computed by dividing the lateral spacing of 60 feet by the required maximum spacing of 65% of the wetted diameter (60 ft ÷ 0.65 = 92.3 ft); (2) the minimum required gpm of the sprinkler. The following formula is used to determine the gpm/spk:

$$\text{App. rate (in./hr)} = \frac{\text{gpm/spk} \times 96.3}{S \times L}$$

Where S = Spacing of sprinklers along lateral

L = Spacing between laterals in feet

For a tentative application rate, divide the gross application of 0.54 inches by the hours operating per day (4 hrs) which results in 0.135 inches per hour. Now solve the formula for gpm/spk:

$$\text{gpm/spk} = \frac{0.135 \text{ in./hr} \times 40 \text{ ft} \times 60 \text{ ft}}{96.3}$$

gpm/spk = 3.36 gpm

With the two sprinkler requirements of 3.36 gpm and 92.3 feet wetted diameter, refer to the sprinkler manufacturer's charts. Table 10-A-1 shows a typical manufacturer's sprinkler data and was used to select the sprinkler. The sprinkler selected has a capability of 3.84 gpm @ 45 psi with a wetted diameter of 92 feet which meets the criteria. The nozzle size is 9/64 inches. This data was entered in Item 9.

Step 9. Complete Item 8.

a. Application rate is recomputed using the formula:

$$\text{Application rate (in./hr)} = \frac{\text{gpm/spk} \times 96.3}{S \times L} = \frac{3.84 \times 96.3}{40 \times 60} = 0.15$$

b. Time per lateral or unit set in hours is computed by dividing the gross application of 0.54 in. by the application rate of 0.15 in./hr. Time per lateral set = 0.54 in. ÷ 0.15 in./hr = 3.6 hr.

c. Determine the number of sprinklers per unit. Divide the field using the drawing prepared in Step 2 into 4 as nearly

equal units as possible. Place the sprinklers, pipe layout and valves on the plan. Label each unit and place it on the drawing. Count the number of sprinklers per unit and enter in Item 8. Units have 88 sprinklers.

d. Determine the actual gpm/unit, Q_A per unit. Multiply the number of sprinklers per unit times the gpm/spk to determine gpm/unit.

Units: 88 spk x 3.84 gpm/spk = 338 gpm

Step 10. Complete the last entry of Item 7. Enter the actual hours operating per day of 3.6 hours as calculated in Step 9.b. The Q is obtained by the following formula:

$$Q_R = \frac{453 \times 5 \text{ acres} \times 0.54 \text{ in. gross application}}{3.6 \text{ hrs operating per day} \times 1 \text{ day per irrigation}} = 340 \text{ gpm}$$

Note that as a check, the Q_A should be approximately equal to Q_R.

Step 11. Determine Total Dynamic Head. Refer to Item 10, as each of the following points are discussed:

a. Size the lateral and submain to determine its head loss. Usually the longest lateral and submain is used to determine the head loss within the irrigation unit. However, ground elevation changes may sometimes cause the maximum head loss to occur elsewhere. This will be discussed a little later in this step. Sheets 4 and 5 of Exhibit 10-A-1 Pipe Sizing Data Sheet were used for this purpose. First, the gpm for the lateral and submain was listed in a cumulative manner beginning with the last sprinkler. The length of pipe carrying the corresponding gpm was then listed. Then using Appendix C, the pipe was sized and corresponding friction head loss (HL_f) in ft/100 ft listed on the data sheet. The pipe is sized so that the velocity of water flow through the pipe is less than or equal to 5 fps. The total friction head loss is determined by multiplying the HL_f (ft/100 ft) x the pipe length (ft) and suming the results. The elevation differences are then totaled and added to the total friction head loss to obtain the total head loss in the lateral. The summation of 6.38 ft was used in the design.

Elevation difference of natural ground between the risers and within an irrigation unit must be evaluated for each design as it can affect the layout of the irrigation unit and the pipe sizing. It affects the layout because the nozzle pressure must be maintained within certain limits in each irrigation unit. These limits are discussed in Step 13.

The effect that elevation difference has on pipe sizing can best be explained using an example. For instance, if

a lateral is to be installed downhill from the mainline, a smaller pipe with higher friction head loss may be used. The elevation difference is downhill (increase in pressure) which offsets the decrease in pressure due to friction head loss. An increasing elevation plays a reverse role often resulting in a larger diameter pipe.

b. The head loss for the irrigation unit is then modified so that the theoretical mid-system sprinkler is operating at the design nozzle pressure. This provides for a more balanced system in that the sprinkler closer to the pump operates at a pressure a little higher than the design nozzle pressure and the farthest sprinkler a little lower in pressure. The head loss can be modified by multiplying the summation of 6.38 ft x 0.5 = 3.19 ft. (The factor 0.75 would be used if this was a single pipe size lateral because approximately 75 percent of the pressure loss in a single pipe size lateral with uniformly decreasing discharge has already occurred at the midpoint of the lateral.) Assume the sprinklers within an irrigation unit are desired to operate at a pressure within ± 10% of the design operating pressure. Technical Guide Code 442 allows maximum variation of ± 20 percent. In this case, with the design operating pressure at 45 psi, the allowable variation in sprinkler operating pressure is ± .10 x 45 psi = ± 4.5 psi. Therefore, 45 psi ± 4.5 psi = 40.5 psi and 49.5 psi for the minimum and maximum sprinkler operating pressure.

c. Size the mainline and determine the head loss. Item 10 could have been used for sizing and determining the mainline head loss since no elevation changes were involved but the pipe sizing data sheet was used for the mainline also. The 6 in. main with 338 gpm has a friction head loss of 0.69 ft/100 ft. Total head loss is equal to 0.69 ft/100 ft x 495 ft = 3.43 ft. The 3.43 ft is equal to 1.48 psi.

d. Determine the recommended maximum working pressure. This is the class of pipe (160 psi) multiplied by 0.72 = 115 psi since it is assumed special surge and water hammer control is not to be provided. Do not compute actual working pressure until later in the design.

e. Design sprinkler nozzle pressure. The 45 psi sprinkler operating pressure was determined in Item 9. Remember that this is the operating pressure of the theoretical mid-sprinkler of the irrigation unit.

f. Miscellaneous and fitting friction losses. This can be computed using the formula $h = (Kv^2/2g)$ where values of K are in Appendix C. However, this is usually estimated to be within a range of 1.3 psi to 3.5 psi depending on the complexity of the system. This example was estimated to have about 1.3 psi head loss for miscellaneous and fitting losses.

g. Riser height. The height required to get the sprinkler above the vegetation to prevent distortion of the water. In this case, 3 feet is required.

h. Pump discharge pressure (at the entrance to the main pipe line). This is the pressure the pump must produce so that the theoretical mid-sprinkler of the irrigation unit is operating at its design operating pressure of 45 psi. To obtain the pump discharge pressure the preceding items were totaled as follows:

Lateral & sub-main friction losses	-	1.38 psi
Mainline friction losses	-	1.48 psi
Nozzle pressure	-	45.00 psi
Miscellaneous & fittings friction losses	-	1.30 psi
Riser height	-	1.30 psi
Pump discharge pressure		50.5 psi

i. Maximum pipe working pressure in main. This is the same as the pump discharge pressure just determined (50.5 psi). From step 11-d, maximum recommended working pressure for the 6" class 160 pipe is 115 psi, thus the pipe strength is adequate throughout.

j. Pumping lift. This is discussed in Chapter 6. It is the vertical distance the pump must lift the water in the well to reach the ground level (main inlet) or in the case of a centrifugal pump the vertical distance plus losses (suction lift) from the water elevation at maximum drawdown to the pump discharge. The pump-drawdown is considered in determining the pumping lift. This example has the static water level at 75 feet with 50 feet of drawdown when pumping. Therefore the pumping lift is 75 ft + 50 ft = 125 ft which is equal to 54.1 psi.

k. Total dynamic head (TDH). This is the total head loss that the pump must operate against in order for it to perform the required work. The pump discharge pressure (50.5) psi + pumping lift (54.1 psi) = 104.6 psi TDH. This is usually expressed in feet which would be 241.6 ft TDH. (use 242 ft.)

l. Net positive suction head available (NPSHA). This represents the energy available to move the fluid(water) into the eye of the impeller.

NPSHA = 144 (Pa - Pv)/w - h_f + z
where the minimum probable value for the term 144 (Pa - Pv)/w @ 70°F @ sea level ≅ 144 (13.57 - 0.37)/ 62.3 = 30.49. use 31 ft. This value (31 ft) may be used throughout the piedmont (up to 1000 ft above sea level) and lower lying areas of S.C. for acceptable accuracy. For higher lying areas (up to about 4000 ft above sea level) the value should be reduced about one ft for each 1000 ft rise in elevation.

h_f = head loss (ft) due to friction in inlet line and at the impeller entrance (use 3 ft as average value in most situtations).

z = elevation difference between pump centerline and the water surface (assume 20' for this example). If the suction water surface is below the pump centerline, z is negative. Therefore, NPSHA ≅ 31 - 3.0 + 20.0 = 48 ft.

Step 12. Complete Item 11, Pump Requirement. This is the maximum gpm the pump must produce at a given TDH and minimum net positive suction head. From Item 8, the maximum Q_A for an irrigation unit is 338 gpm. The TDH from the preceding section is 242 feet. The NPSH required must be less than 48 ft. Therefore, the pump requirement would be expressed as 338 gpm at 242 feet TDH with NPSH less than 48 ft.

Step 13. Complete Item 12. Power Unit Requirement. This is the brake horsepower needed at the output from the power unit to supply power to the pump. The pump efficiency would be obtained from the characteristics curve for the particular pump to be used. A value of 0.70 would be a reasonable value for some pumps, use 0.7. The drive efficiency for a direct connected electric motor is approx. 100 percent, use 1.00. Therefore, compute BHP using gpm and TDH from the preceeding step.

$$BHP > \frac{338 \text{ gpm} \times 242 \text{ ft TDH}}{3960 \times 0.7 \times 1.0} = 29.5$$

Step 14. Complete Item 13. Check the sprinkler pressure variation within the system (Irrigation Units) against the allowable. This was discussed earlier under Item 11.b. The actual is found by using sheet 4 of 5 of Exhibit 10-A-1. The actual nozzle pressure of the closer sprinkler is the pump discharge pressure (50.5 psi) - the mainline losses (1.48 psi) - miscellaneous and fitting friction losses (1.30 psi) - the riser height loss (1.30 psi) = 46.4 psi. The actual nozzle pressure of the farthest nozzle is the pump discharge pressure (50.5 psi) - the mainline loss (1.48 psi) - miscellaneous and fitting friction losses

(1.30 psi) - the riser height loss (1.30 psi) - actual total lateral and sub-main losses (2.8 psi) = 43.6 psi.

The allowable nozzle pressure as taken from section 11.b. is 40.5 psi (minimum) and 49.5 psi (maximum). The actual nozzle pressure of 43.6 psi and 46.4 psi is within this range.

Table 10-A-1. Typical Sprinkler Manufacturer's Data

Highest point of stream is 7' above nozzle.*

psi@ Nozzle	Nozzle 7/64" diam	gpm	Nozzle 1/8" diam	gpm	+Nozzle 9/64" diam	gpm	Nozzle 5/32" diam	gpm	Nozzle 11/64" diam	gpm
25	78	1.73	82	2.25	85	2.90	88	3.52	90	4.24
30	79	1.89	84	2.47	87	3.16	90	3.85	92	4.64
35	80	2.05	85	2.68	89	3.40	92	4.16	94	5.02
40	81	2.20	86	2.87	91	3.63	94	4.45	96	5.37
45	82	2.32	87	3.05	92	3.84	96	4.72	98	5.70
50	83	2.44	88	3.22	93	4.04	98	4.98	100	6.01
55	84	2.56	89	3.39	94	4.22	100	5.22	102	6.30
60	85	2.69	90	3.55	95	4.28	101	5.54	103	6.56

+Standard Nozzle.
*Shown for standard nozzle at normal operating pressure. Area below dotted line in chart is the recommended working pressure for best distribution.

LAYOUT CONSIDERATIONS

Items that must be considered in the layout of a permanent and solid-set irrigation system area as follows:

a. Soil limitations which may affect the ease of installation such as cut banks caving, depth to rocks and wetness.

b. Plant spacing and row direction so that riser can be properly located.

c. Maximum height of plants for determing riser height.

d. Location of obstacles such as ponds, fences, overhead power lines and buried electrical and gas lines which are safety hazards.

e. Topography which may affect the layout of the system and valving arrangement so that each irrigation unit can be operated within the allowable pressure variation.

CONSTRUCTION REQUIREMENTS

Construction items that must be checked to be assured of a quality installation are as follows:

a. The depth of cover over the buried main line must be adequate for protection from vehicular traffic and the farming operation.

b. Thrust block dimensions, location and alignment to prevent pipe joint separation.

c. Location and size of air vents and pressure relief valve. Risers function as air vents but others may be required if a pipeline has a summit with no riser.

d. Riser material, diameter, height and spacing.

e. Sprinkler model and size nozzle. Location of part circle sprinklers if planned.

f. Location and size of valves which serve each irrigation unit.

g. Depth of cover over the buried pipe.

h. Verify the pipe requirements such as SDR number, pressure rating, ASTM designation, PVC material, pipe diameter and if PIP or IPS pipe.

i. Check valve installed at pump discharge.

j. Verify pump, motor and well size. Then check the nozzle pressure and variation within each irrigation unit using a pressure gauge with a pitot tube.

IRRIGATION DATA SHEET

System type (circle): Center Pivot, Traveling Gun, (Permanent, Solid Set) (Other, list)

CONSERVATION DISTRICT Aiken FIELD OFFICE Aiken
COOPERATOR John Doe LOCATION 11 Co.
IDENTIFICATION NO. System No. 1 FIELD NO. 2

1. Design area 20 acres (Area actually irrigated)
Soil series Dothan

Design Soil Series: Dothan Predominate maximum slope 4 %

Soil Depth (in.)	Texture (USDA)	Average AWC (in./in.)
0-11	L.S.	.08
11-31	S.L.	.14
use 0-12	LS	.08

2. Crops:

Crop	Acres	Planting Date	Maturity Date
S. Veg.	20	Varies	Varies
Total	20		

3. Water supply:
Source of supply: (stream, (well), reservoir, etc.) 12"

Stream: Measured flow (season of peak use) — gpm

Reservoir: Storage — ac. ft. Available for irrigation — ac. ft.

Stream or Reservoir: Maximum drawdown available — ft.; Maximum elevation lift on intake side of pump — ft.

Well: Static Water Level 75
Measured Capacity 400 gpm @ 50 ft drawdown
Design Pumping Lift 125 ft (to ground level - main pipeline inlet)
Pump Impeller Level 140

Distance supply source (main pipeline inlet) to field 0 ft

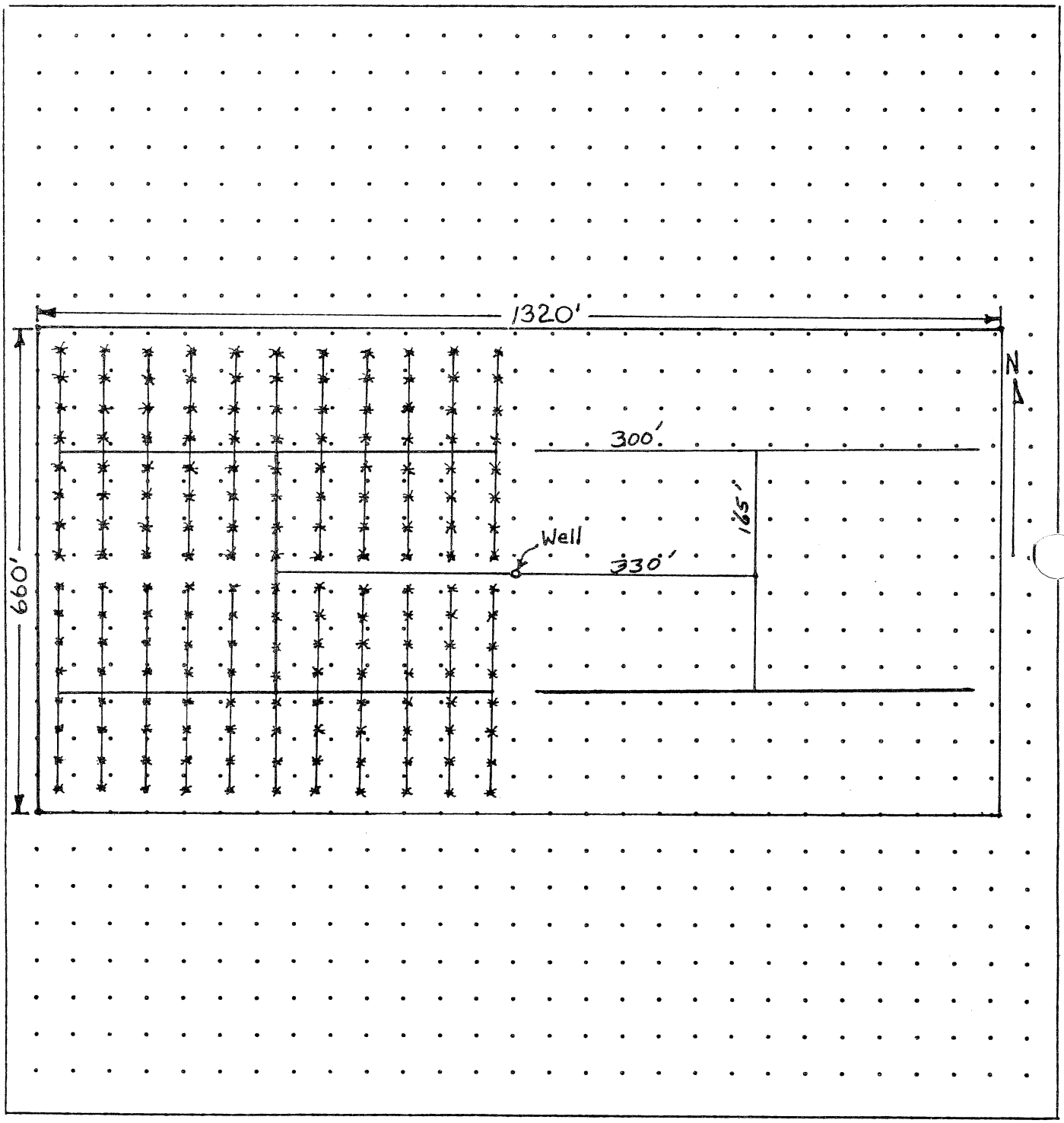
Quality of water (evidence of suitability): No apparent problems

4. Other Data:
Type of power unit and pump to be used: Electric - 3 Ph.

PERM./SOLID-SET SPRINKLER IRRIG. SYSTEM

Cooperator: John Doe Designed by: Tom Jones Checked by: A. Engineer

5. Map of design area - Scale 1" = 200 ft
Sketch map on grid or attach photo or overlay.



Sketch map should show:

a. Source of water
b. Major elevation differences
c. Row direction
d. Sprinkler system layout
e. Plan of operation
f. Field obstructions (gullies, trees, buildings, etc.)
g. North arrow

PERM./SOLID-SET SPRINKLER IRRIG. SYSTEM

Cooperator: John Doe Designed by: Tom Jones Checked by: A. Eng.

6. Crop Information	IRRIGATION UNIT NUMBER 1	2	3	4
Kind of crop	small veg.	→		
Acreage to be irrigated (acres) 1/	5	5		
Depth of soil water control zone (in.)	12	9		
Peak use rate (in./day)	0.18	.18		
Weighted AWC for water control zone(in./in)	0.08	.12		

7. Design Procedure				
AWC within water control zone (in.)	0.96	1.08		
Depletion allowed prior to irrigation (%)	40	50		
Maximum net water allowed per irrig. (in.)	0.38	.54		
Net water applied per irrigation (in.)	0.38	.54		
Max. recommended application rate (in./hr.)	No limit	.4"/hr		
System efficiency (%)	70	75		
Gross application per irrigation (in.) 1/	0.54	.72		
Peak irrigation interval (days)	2.1	3.06		
Irrigation Period (days per irrig.)	1	1		
Hours operating per day	4	6		
Q_R = Quantity of water required (gpm) 1/	340	16		

8. Irrigation Unit Design				
Application Rate (in./hr) 2/	0.15	.13		
Actual Time per lateral or unit set (hrs = gross application / application rate)	3.6	5.6		
Number of sprinklers per unit	88	4		
Q_A 3/ = Quantity of water actual (gpm/unit) = No. of sprinklers/unit x gpm/spk.)	338	16		

9. Sprinkler Specifications:
   a. sprinkler spacing 40 ft, lateral spacing 60 ft
   b. nozzle size 9/64" x — wetted diameter 92 ft
   c. capacity 3.84 gpm @ 45 psi or 104 ft

1/ Q_R = 453 x 5 acres x 0.54 in. gross application = 306 gpm
4.0 hrs opr. per day x 1 days per irrigation

2/ Application rate (in./hr) = $\frac{\text{gpm/spk x } 96.3}{S \times L}$ MUST BE ≤ MAXIMUM RECOMMENDED RATE

Where S = Spacing of sprinklers along lateral in feet.
L = Spacing between laterals in feet.

3/ Q_A = maximum unit gpm: Must be approximately equal to Q_R

PERM./SOLID-SET SPRINKLER IRRIG. SYSTEM

Cooperator: John Doe Designed by: Tom Jones Checked by: A. Eng.

10. Determining Total Dynamic Head 4/

Kind of Pipe			Design Capacity (gpm)	IPS PIP Other___ Diameter (in.)	Length (ft)	Friction Head Loss 5/ (ft/100ft)	Total Head Loss HL (ft)	Total Head Loss, HL		Working Pressure	
Main	Sub-Main	Lateral						(ft)	(psi)	Recommended Max 6/ (psi)	Actual Max. (psi)
XXXX	✓	✓	(see attached pipe calculations)				6.38	XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	6.38	3.19 7/	1.38		
✓	XXXX	XXXX					XXXX	3.43	1.48	115.	50.5
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
Design Sprinkler Nozzle Pressure								104.0	45.0		
Miscellaneous and Fitting Losses (usually 3 psi +)								3.0	1.3		
Riser Height								3.0	1.3		
Pump Discharge Pressure (at main pipeline inlet)								116.6	50.5		
Pumping Lift (including losses)								125.0	54.1		
Total Dynamic Head, TDH								241.6	104.6		
Estimated Net Positive Suction Head Available, NPSHA								48	—		

11. Pump Requirements: 338 gpm @ 104.6 psi or 242 ft of head and NPSH less than 48 ft.

12. Power Unit Requirement:

$$BHP \geq \frac{338 \text{ gpm} \times 242 \text{ ft TDH}}{3960 \times 0.7 \text{ pump eff.} \times 1.0 \text{ drive eff.}} = 29.5$$

13. Check pressure variation within system (irrigation unit).
    Allowable = ± 10 % of nozzle operating pressure = ± 4.5 psi.
    Allowable = 40.5 psi to 49.5 psi
    8/ Actual = 43.6 psi to 46.4 psi

4/ Use pipe sizing data sheets where elevation differences are present and/or additional data lines needed.
5/ Keep velocity ≤ 5 fps unless means to control surge and water hammer are otherwise adequate.
6/ For plastic pipe, pressure rating divided by 0.72 unless means to control surge and water hammer are otherwise adequate.
7/ Sets optimum nozzle pressure at a theoretical mid-system sprinkler.
8/ Consider elevations and location. Adjust 7/ if possible to stay within allowed variation. If not, the system must be redesigned.

Design approved by: Tom Jones Date: 3/2/86

PIPE SIZING DATA SHEET

Cooperator John Doe
Field Office Aiken

Sheet 5 of 5
Designed by Tom Jones
Checked by A. Engineer

Irrigation Unit No. ____			Pipe Sizing Calculations								Pipe Material PVC, SDR 26 IPS☑ PIP☐ Other____
Main	Sub-Main	Lateral	Design Capacity (gpm)	Pipe Diam. (in.)	Length (ft)	HL_f (ft/100')	Multiple Outlet Factor	Total HL_f (ft)	Elevation Difference HL_e (ft)	Total HL $HL_f + HL_e$ (ft)	Remarks
		✓	3.84	1	40	0.49		0.20	0.20	0.40	(All pipe is PVC
		✓	7.68	1	40	1.79		0.72	0.10	0.82	type 1120 material)
		✓	11.52	1¼	40	1.16		0.47	0.10	0.57	
		✓	15.36	1¼	20	1.94		0.39	0.20	0.59	
	✓		30.72	2	60	1.21		0.73	-0.20	0.53	
	✓		61.44	2½	60	1.72		1.03	-0.10	0.93	
	✓		92.16	3	60	1.41		0.85	0	0.85	
	✓		122.88	3½	60	1.25		0.75	0.10	0.85	
	✓		153.60	4	60	1.06		0.64	0.20	0.84	
							Σ	5.78	0.60	6.38	½ Total HL = 6.38/2 = 3.19 [1]
✓			337.92	6	495	0.69		3.43	0	3.43	class 160 pipe

[1] Modification to provide for theoretical mid-system sprinkler to be at optimum pressure used for design.

10-A-15

CHAPTER 10-B. TRAVELING GUN SPRINKLER IRRIGATION SYSTEM

GENERAL

The example problem in this chapter is intended to illustrate the procedure to follow in the design of traveling gun irrigation systems. It is understood that one example cannot explain all design situations or alternatives to consider when designing traveling gun sprinkler irrigation systems.

DESIGN CRITERIA

Design criteria for traveling gun sprinkler irrigation system is contained in Technical Guide, Irrigation System, Sprinkler, Code 442, for South Carolina. All traveling gun sprinkler irrigation system must be designed in accordance with the criteria contained in Code 442. Guidelines for line spacings may be obtained from this chapter.

EXAMPLE PROBLEM

The following example problem is intended to cover the basic design steps to follow in the design of traveling gun sprinkler irrigation systems. A standard form (Exhibit 10-B-1) is used which is a useful tool in designing and recording data.

Given:

1. Existing Nelson 200 gun, 27° trajectory, 1 3/4" Ring Nozzle, 270° angle of operation.

2. Crop & Acres: 40 acres soybeans
   28 acres peanuts

3. Soil: Fuquay Sand

4. Location: Orangeburg, South Carolina

5. Slope: Maximum 6%

6. Pump capability (existing): 500 gpm @ 320 ft TDH; 600 gpm @ 350 ft TDH; 700 gpm @ 400 ft TDH

7. Crop Rows: North and South

Solution:

All item numbers mentioned in the step by step solution refer to the items on the standard form "Irrigation Data Sheet" in Exhibit 10-B-1.

Step 1. Complete Items 1-4. These items provide an inventory of pertinent data of the site.

Step 2. Complete Item 5. Make a drawing to scale of the field locating trees, buildings, well and other features.

Step 3. Complete Item 6. Guidance in selecting the moisture extraction root depths (soil water control zone) and the design peak use rate are to be taken from this guide, Tables 3-1 and 4-1 respectively. The weighted AWC is computed using data from item 1.

Step 4. Complete the following parts of Item 7 (the figures used in the following steps will be specifically oriented to the soybeans, the crop with the larger peak consumptive use).

a. Available water capacity (AWC) within the water control (root) zone is the product of the root zone moisture extraction depth (24 inches) times the moisture holding capacity of the soil (0.05 in./in.) AWC = (24 in.)(0.05 in./in.) = 1.20 in.

b. The percent depletion allowed prior to irrigation is selected to be 50%.

c. The maximum net water applied per irrigation (in.) is the product of the percent depletion allowed prior to irrigation (50%) times the water available within the root zone. The maximum net water applied per irrigation is = (0.50)(1.2 in.) = 0.60 in.

d. The net water to be applied should be less than or equal to the maximum allowed. Use the maximum for this example - 0.6 inches.

e. Maximum application rate from table 2-6. Use 0.8" per hour or less.

f. The water application efficiency is selected to be 70% (average for day and night irrigation).

g. The gross water applied per irrigation (in.) is the net water applied (0.60 in.) divided by the system efficiency (70%). Gross water applied = 0.60 in. $\div$ 0.7 = 0.86 in.

h. The peak irrigation interval (days) is the net water applied (0.60 inches) divided by the design peak use rate (0.30 in./day). Peak irrigation interval = 0.60 in. $\div$ 0.30 = 2.0 days.

i. The irrigation period to be used in the formula for determing the Q_R is the irrigation interval, 2.0 days.

j. The hours operating per day were discussed with the owner who advised that he irrigated continuously until completed. Therefore, the 20 hours were agreed upon providing another 4 hours for moving the equipment.

k. Now determine the quantity of water required (gpm) using the formula as follows:

$$Q_R = \frac{453\ Ad}{FH}$$ (See page 10-A-3 for explanation of formula.)

$$Q_R = \frac{453 \times 68 \text{ acres} \times 0.86 \text{ inches gross application}}{20 \text{ hrs opr. per day} \times 2.0 \text{ days per irrigation}}$$

$$Q_R = 662 \text{ gpm}$$

Step 6. Complete Item 8, Irrigation Unit Design.

a. Keeping in mind the capability of the pump (see sheet 10-B-1) and the minimum Q required of 662 gpm, determine the nozzle size, sprinkler gpm, and nozzle pressure. Using the Volume Gun Performance Tables (Table C-27) with a ring nozzle size of 1 7/8 inches, a capacity of 675 gpm at 80 psi and a wetted diameter of 470 feet was selected.

b. Determine the lane spacing using approximately 60-65% of the wetted diameter of the sprinkler assuming a wind speed of 5 to 10 mph (see Table 10-B-1, p. 10-B-7). The total length of the field is 1,660 feet. The spacing of 290 ft between risers was tentatively selected which is 62% of the wetted diameter. Now, in order to properly irrigate the ends of the field, the riser needs to be approximately 75% of the wetted radius away from the field boundary (i.e., .75 x 235 ft) or 176 feet. Now determine the distance actually available by dividing the distance 1,800 ft. by 290 ft. = 6.21 spaces. Take 1.21 spaces x 290 ft/space = 350 ft. and place half of this (175 ft) distance at each end of the field between the riser and field boundary. The 175 feet is adequate.

c. The application rate is computed using the following formula:

$$\text{Application rate (in./hr)} \cong \frac{96.3 \times \text{sprinkler gpm, } q}{(0.81)\ 3.14\ (r)^2} \times \frac{360}{w}$$

$$= \frac{13630 \times q}{r^2\ w}$$

where r = wetted diameter/2 = 235'
w = portion of circle receiving water, degrees, use 270.

$$\text{Application rate} = \frac{13630 \times 675}{(235)^2\ 270} = 0.62 \text{ in./hr.}$$

d. The travel speed is computed by the following formula:

$$\text{Travel Speed (ft/min)} = \frac{1.605 \times \text{sprinkler gpm}}{\text{lane spacing (ft)} \times \text{gross water applied (in.)}}$$

$$= \frac{1.605 \times 675}{290 \times 0.86} = 4.34 \text{ ft/min for soybeans}$$

e. $$\text{Time per 660 ft. run (hrs)} = \frac{660 \text{ ft}}{4.34 \text{ ft/min}} \times \frac{1 \text{ hr}}{60 \text{ min}}$$

$$= 2.53 \text{ hours}$$

Step 7. Complete Item 9, Sprinkler Specification.

Step 8. Make a scaled plan layout of the system. Pipe sizes etc., will be added later.

Step 9. Complete Item 10. Size the mainline and determine the Total Dynamic Head required for the pump:

a. Use a 8-inch diameter PVC, SDR 26, class 160 IPS pipe. A length of 1725 ft was determined from the layout. The friction head loss is 0.69 ft/100 ft and is taken from Appendix C. The total head loss for the 8-inch PVC is 0.69 ft/100 ft x 1725 ft = 11.9 ft. The recommended maximum working pressure in the pipe is 0.72 x 160(class rating) = 115 psi since it is assumed special means to control surge and water hammer will not be provided. Do not enter the actual working pressure yet.

b. Using 660 ft of 5 inch flexible hose, the friction loss taken from Exhibit C-1 is 2.0 psi/100 ft or 4.62 ft/100 ft. Total head loss for the hose is 660 ft x 4.62 ft/100 ft = 30.5 ft. Table 10-B-2 is a guide for flexible hose selection.

c. Enter the sprinkler pressure at the nozzle, miscellaneous losses and elevation differences between the main pipeline inlet and the nozzle when located on the high point in the field.

d. The sum of a, b, and c gives a pump discharge pressure at the main pipeline inlet required of 249.1 feet of head or 107.84 psi. Enter this value also as the actual maximum working pressure in the main.

e. The pumping lift (suction lift in this example) is the sum of the static suction lift and friction losses in suction pipe and miscellaneous inlet fittings. The static suction lift is 15 ft. from item 3. The friction loss in 6 inch inflow line (30 linear ft, 5" PVC SDR-26) is 5.9 ft/100 ft x 30 ft = 1.77 ft. The losses in the inlet fittings may be calculated using appropriate head loss coef. k from Table C-18. Usually these losses are $\leq$ 2 feet, use 2 ft. The total pumping lift is approximately 15.0 + 1.77 + 2.0 = 18.77 (use 19 ft).

f. The total dynamic head is the pumping lift plus the pump discharge pressure, 19.0 ft + 249.1 ft = 268.1 ft = 116.06 psi.

g. The minimum net positive suction head available (NPSHA) is approximately equal to 31.0 - suction lift = 31.0 - 19.0 = 12.0 ft (see example in section 10-A and Chapter 6 of this guide for more information).

Step 10. Complete item 11. The pump requirement of 675 gpm at 268 feet of head (TDH) is within the capability of the pump. Although not given for this pump, the NPSH required must be less than about 12.0 ft or cavitation is likely.

Step 11. Complete item 12, Power Unit Requirement. This is the brake horsepower needed at the output from the power unit to supply power to the pump. The pump efficiency would be obtained from the characteristics curve for the particular pump to be used. A valve of 0.70 would be a reasonable value for some pumps, use 0.7. The drive efficiency for a direct connected electric motor is approximately 100 percent, use 1.00. Therefore, compute BHP using gpm and TDH from the preceeding step.

$$BHP \geq \frac{675 \text{ gpm} \times 268 \text{ ft TDH}}{3960 \times 0.7 \times 1.0} = 65.3$$

Step 12. Complete the plans. The specifications, location of the pipe, check valve, air vents, pressure relief valve, risers, thrust blocks, etc., should be shown on the plans. See sheet 2 of 5 of Exhibit 10-B-1.

LAYOUT CONSIDERSATIONS

Items that must be considered are as follows:

a. Plant spacing and/or row direction so that travel lanes can be located properly.

b. Location of obstacles and safety hazards.

c. Whenever possible, place the risers a full hose length away from the edge of the field. This greatly facilitates laying out the hose and reeling it back up.

d. Soil limitations such as surface texture may necessitate a part circle volume gun so that the area is not irrigated in front of the gun as it moves, providing a dry footing.

e. Topography may dictate the lane direction to prevent misalignment of the traveler while in operation.

CONSTRUCTION REQUIREMENTS

The following is a list of construction items that should be checked to be assured of a quality installation:

a. The depth of cover over the buried mainline must be adequate for protection from vehicular traffic and the farming operation.

b. Thrust block dimensions and location to prevent pipe joint separation.

c. Location and size of air vents and pressure relief valve.

d. Size and proper direction of installed check valve.

e. Riser material, size, number and location.

f. Verify the pipe requirements such as SDR number, pressure rating, ASTM designation, PVC material, pipe diameter and if PIP or IPS size.

g. Verify pump, motor and well size. Check nozzle pressure.

Sprinkler Wetted Diameter	Percent of Wetted Diameter						
	50	55	60	65	70	75	80
	Wind over 10 mph		Wind up to 10 mph		Wind up to 5 mph		No Wind
ft	ft	ft	ft	ft	ft	ft	ft
200	100	110	120	130	140	150	160
250	125	137	150	162	175	187	200
300	150	165	180	195	210	225	240
350	175	192	210	227	245	262	280
400	200	220	240	260	280	300	320
450	225	248	270	292	315	338	360
500	250	275	300	325	350	375	400
550	275	302	330	358	385	412	440
600	300	330	360	390	420	---	---

Table 10-B-1. Recommended towpath spacings for traveling sprinklers with ring (lower) and tapered (higher percentages) nozzles

FLOW RANGE (gpm)	HOSE DIAMETER (Inches)
50 - 150	2.5
150 - 250	3.0
200 - 300	3.5
250 - 600	4.0
400 - 750	4.5
500 - 1000	5.0

Table 10-B-2. Guide for Flexible Irrigation Hose Selection (See Exhibit C-1, p. C-16 for friction loss table)

IRRIGATION DATA SHEET

System type (circle): Center Pivot, (Traveling Gun,) _____
(Other, list)

CONSERVATION DISTRICT Orangeburg FIELD OFFICE Orangeburg
COOPERATOR John Farther LOCATION 11 Co.
IDENTIFICATION NO. System No. 3 FIELD NO. 3

1. Design area 68 acres (Area actually irrigated)
Soil series Fuquay

Design Soil Series: Fuquay Predominate maximum slope 4 %

Soil Depth (in.)	Texture (USDA)	Average AWC (in./in.)
0-24	Sand	0.05

2. Crops:

Crop	Acres	Planting Date	Maturity Date
Peanuts	28	4/20	9/7
Soybeans	40	5/1	9/30
Total	68		

3. Water supply:
Source of supply: (stream, well, reservoir, etc.) stream

Stream: Measured flow (season of peak use) 1000+ gpm

Reservoir: Storage — ac. ft. Available for irrigation — ac. ft.

Stream or Reservoir: Maximum drawdown available 4 ft.; Maximum elevation lift on intake side of pump 15 ft.

Well: Static Water Level —
Measured Capacity — gpm @ — ft drawdown
Design Pumping Lift — ft (to ground level - main pipeline inlet)
Pump Impeller Level —

Distance supply source (main pipeline inlet) to field 1000 ft

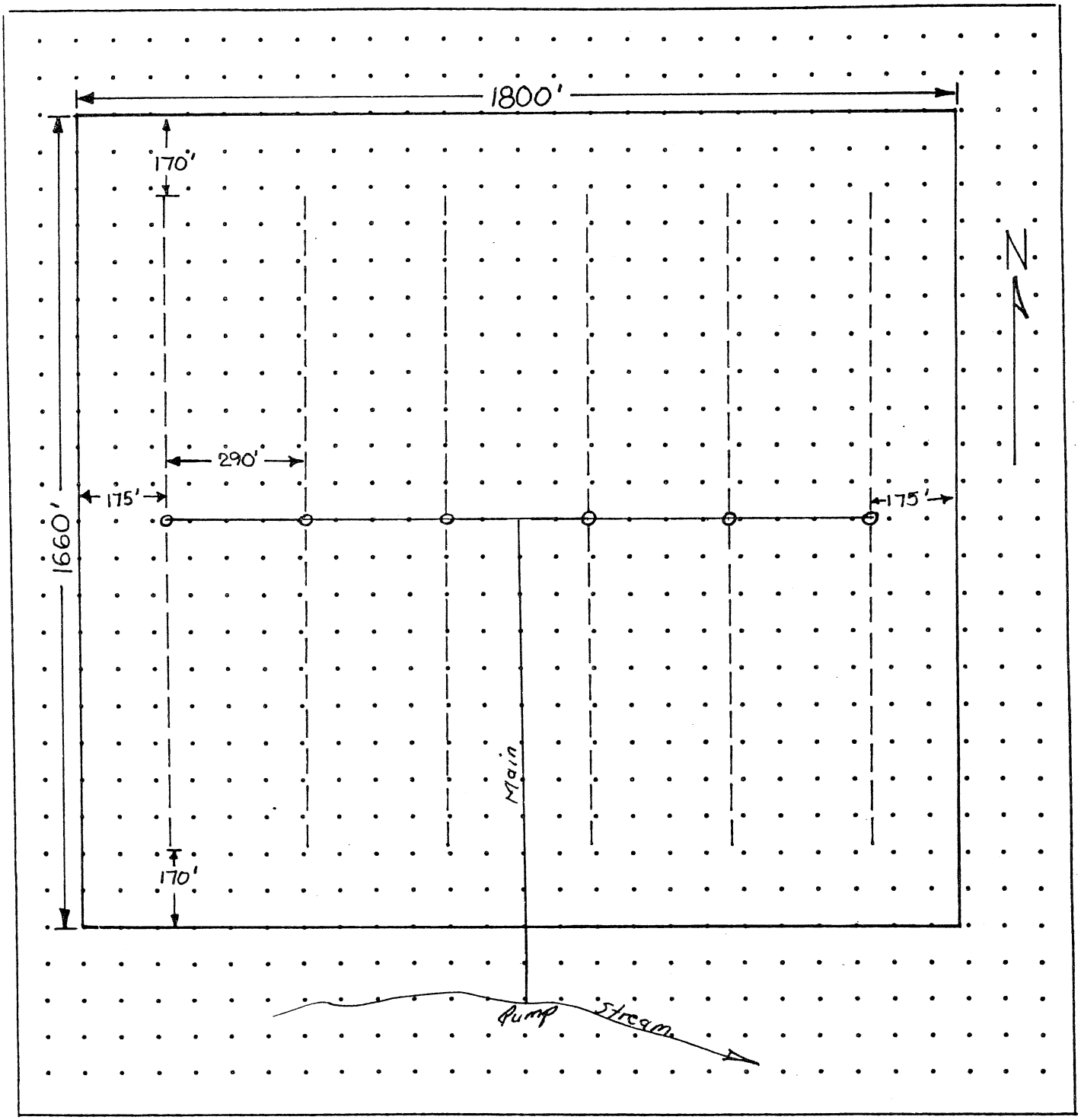
Quality of water (evidence of suitability): Good

4. Other Data:
Type of power unit and pump to be used: Diesel

TRAVELING GUN IRRIGATION SYSTEM Sheet 2 of 4

Cooperator: John Farmer Designed by: Walter Jones Checked by: A. Engineer

5. Map of design area - Scale 1" = 300 ft
Sketch map on grid or attach photo or overlay.



Sketch map should show:

a. Source of water
b. Major elevation differences
c. Row direction
d. Sprinkler system layout
e. Plan of operation
f. Field obstructions (gullies, trees, buildings, etc.)
g. North arrow

TRAVELING GUN IRRIGATION SYSTEM

Cooperator: J. Farmer Designed by: W. Jones Checked by: J. Stone

6. Crop Information	IRRIGATION UNIT NUMBER 1	2	3	4
Kind of crop	Peanuts	Soybeans	Soybeans	
Acreage to be irrigated (acres) 1/	28	40	68	
Depth of soil water control zone (in.)	18	24	24	
Peak use rate (in./day)	.25	.30	.30	
Weighted AWC for water control zone(in./in)	.05	.05	.05	
7. Design Procedure				
AWC within water control zone (in.)	0.9	1.2	1.2	
Depletion allowed prior to irrigation (%)	50	50	50	
Maximum net water allowed per irrig. (in.)	0.45	0.6	0.6	
Net water applied per irrigation (in.)	0.45	0.6	0.6	
Max. recommended application rate (in./hr.)	0.8	0.8	0.8	
System efficiency (%)	70	70	70	
Gross application per irrigation (in.) 1/	0.64	0.86	0.86	
Peak irrigation interval (days)	1.8	2.0	2.0	
Irrigation Period (days per irrig.)	1.8	2.0	2.0	
Hours operating per day	20	20	20	
Q_R = Quantity of water required (gpm) 1/	225	390	662	
8. Irrigation Unit Design				
Q_A 2/ = Quantity of water actual (gpm)			675	
Application rate (in./hr) 3/			0.62	
Travel Speed(ft/min) 4/ Lane Spacing, 290 ft			4.34	
Travel Speed(ft/min) 4/ Lane Spacing, ft				
Time per 660' run (hrs) Lane Spacing, 290 ft			2.53	
Time per 660' run (hrs) Lane Spacing, ft				

9. Sprinkler Specifications:
   a. Lane Spacing 290 ft
   b. Nozzle Size 1 7/8 in. (ring) or taper (circle); Wetted Diam. 470 ft; Capacity 675 gpm @ 80 psi; Trajectory Angle 27 degrees; Degrees of coverage 270
   c. No. of sprinklers operating simultaneously 1
   d. Total design capacity all sprinklers 662 gpm

1/ Q_R = 453 x 68 acres x 0.86 in. gross application / 20 hrs opr. per day x 2 days per irrigation = 662 gpm

2/ Q_A must be $\geq Q_R$

3/ Application rate = $\frac{13630 \times \text{sprinkler gpm}}{(\text{radius of wetted circle})^2 \text{ (Degrees of coverage)}}$

4/ Travel Speed = $\frac{1.605 \times \text{sprinkler gpm}}{\text{Lane Spacing, ft, x gross water applied, in.}}$

TRAVELING GUN IRRIGATION SYSTEM

Co rator: _____ Designed by: _____ Checked by: _____

10. Determing Total Dynamic Head: (Total main line length _____ ft.)

Kind of Pipe & SDR, Sch, Class,etc	Pipe Size (in.)	Design Capacity (gpm)	IPS: PIP: PIPE SIZING Length (ft)	Friction Head Loss[5/] (ft/100 ft)	HOSE SIZING[6/] Length (ft)	Friction Head Loss (ft/100ft)	Total Head Loss (ft)	Total Head Loss (psi)	Working Pressure Recommended max[7/] (psi	Working Pressure Actual Max. (psi)
Hose Inlet Pressure[8/] or either Sprinkler Pressure at Nozzle (circle which)										
Misc. & Fitting Losses (usually 3 psi +)[9/]										
Elevation Difference[10/]										
Pump Discharge Pressure @ (Main Pipeline Inlet)										
Pump Lift (Including losses)										
Total Dynamic Head, TDH										
Estimated Net Positive Suction Head Available, NPSHA										

11. Pump Requirements:
Capacity _____ gpm @ _____ psi or _____ ft of head
and NPSH less than _____ ft

12. Power Unit Requirement:

$$BHP \geq \frac{\text{_____ gpm} \times \text{_____ ft TDH}}{3960 \times \text{_____ pump eff.} \times \text{_____ drive eff.}} = \text{_____}$$

5/ Keep velocity ≤ 5 fps unless means to limit surging and water hammer are otherwide adequate.

6/ Omit this section if required hose inlet pressure is known and is used in TDH calculations.

7/ For plastic pipe 72 percent of the pressure rating unless means to limit surge and water hammer are otherwise adequate. The use of lay-flat hose should help to limit surge presures due to flexibility of the hose and its expansion properities.

8/ Mfg. recommended pressure plus one-half the elevation difference (plus or minus) from hose inlet to highest point in the field along the lanes.

9/ Traveler turbine losses (approx. 10 psi) would need to be added as applicable.

10/ Difference in elevation either from well or pump discharge and the elevation of the highest hose inlet or nozzle (plus or minus) in the field along the lanes.

Design Approved By: _____ Date _____

SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 10-C. CENTER PIVOT IRRIGATION SYSTEMS

GENERAL

The example problems in this chapter are intended to illustrate the procedure used in the design of center pivot irrigation systems. It is understood that these two examples cannot show all design situations or all alternatives to consider when designing a center pivot irrigation system. Most often center pivot irrigation systems are designed by the manufacturer and evaluated by the engineer.

DESIGN CRITERIA

Design criteria for center pivot irrigation systems are contained in the Technical Guide, Irrigation System, Sprinkler, Code 442, for South Carolina. All center pivot systems must be designed in accordance with applicable requirements contained in Code 442.

FORMULA USED IN DESIGN AND EVALUATING CENTER PIVOT IRRIGATION SYSTEMS

The following formulas are used in the design and evaluation of center pivot irrigation systems:

a. Total capacity requirements based on known application depth, area and time of application.

$$Q = \frac{453\ Ad}{FH}$$

Where: Q = Total system discharge capacity in gpm
A = Acreage of the design area to be sprinkler irrigated in acres.

d = Gross depth of application in inches.
F = Number of days allowed for completion of one irrigation.
H = Number of actual operating hours per day

b. Application rate from center pivot systems.

$$I = \frac{96.3\ Qs}{S_B\ D}$$

Where: I = Average application rate in inches per hour
Qs= Discharge from individual sprinkler in gpm
D = Wetted diameter of sprinkler nozzle in feet
S_B= Spacing of nozzles along the boom in feet
96.3= Units conversion constant = (12 in/ft)(60 min/hr) ÷ (7.48 gal/cu.ft.)

c. Gross application depth in inches from individual sprinklers on a center pivot.

$$d = \frac{Qs}{0.62\ S_B\ v}$$

Where : d = Application depth in inches (gross)
v = Velocity of rotational speed of individual sprinkler around the pivot point in feet per minute
0.62 = Units conversion constant = 7.48 gal/ft^3 divided by 12 in./ft.

d. Equations b. and c. can be combined to relate terms into a relationship sometimes useful.

$$v = \frac{D\ I}{60\ d}$$

e. End gun discharge, q_g (gpm)

$$q_g = Q\ (1-(L^2/R^2))$$

Where: L = the length of the lateral pipe (ft)
R = L plus 90 percent of the radius wetted by the end gun (ft)
Q = total system capacity (gpm)

EXAMPLE PROBLEM

The following example illustrates a typical problem. Since center pivots are designed by the manufacturer using computers, this example could apply to many situations in which SCS merely would be providing soils and other data or either could be evaluating a system design. SCS could provide data sheets partially completed to the landowner.The landowner then could have an irrigation company provide pertinent design data on the forms and return them to SCS. An SCS employee then could complete the data sheets as a permanent record for future reference and provide copy to the landowner.

Given:

1. Crop & acres: 185 acres corn.

2. Soil: Fuquay Sand

3. Location: Orangeburg, South Carolina

4. Well: 16 inch.

5. No existing pump.

6. Power unit to be diesel.

7. Slope: 0-6%.

8. End gun will not be used for this system.

Solution:

The item numbers mentioned in the step by step solution refer to the items on the standard form "Irrigation Data Sheet" in Exhibit 10-C-1.

Step 1. Complete Items 1-4. These items provide pertinent data of the site.

Step 2. Complete Item 5. Make a drawing to scale of the field locating trees, buildings, well and other features.

Step 3. Complete Item 6. Guidance in selecting the moisture extraction rooting depths (soil moisture control zone) and the design peak use rate are to be taken from Tables 3-1 and 4-1 respectively. The weighted AWC is computed using data from Item 1.

Step 4. Complete the following parts of Item No. 7.

a. Available water capacity (AWC) within the water control (root) zone is the product of the root zone moisture extraction depth (24 in.) times the AWC of the soil (0.05 in./in.)
AWC = 24 in. x 0.05 in./in. = 1.20 in.

b. The percent depletion allowed prior to irrigation is selected to be 50%.

c. The maximum net water allowed per irrigation is the product of percent depletion allowed prior to irrigation (50%) times the available water within the root zone (1.20 in.). The maximum net water allowed = 0.50 x 1.20 in. = 0.60 in.

d. The net water to be applied should be less than or equal to the maximum allowed. Use the maximum for this example - 0.6 inches.

e. Maximum application rate from Table 2-6 for sand, 0.6" water applied, & 5% predominate maximum slope = (No limit).

f. The system efficiency is assumed to be 70%.

g. Gross water applied per irrigation is the net water applied (0.60 in.) divided by the system efficiency (0.70). Gross water applied = 0.60 in. / 0.70 = 0.86 in.

h. The peak irrigation interval is the net water applied (0.60 in.) divided by the design peak use rate (0.30 in./day)= 2.0 days.

i. The irrigation period to be used in the formula for determining Q_R is the irrigation interval 2.0 days.

j. The hours operating per day is 22 hours.

k. The quantity of water required (gpm) is computed using the formula:

$$Q_R = \frac{453 \times \text{____ acres} \times \text{____ inches gross application}}{\text{____ hours operating per day} \times \text{____ days per irrigation}}$$

$$Q_R = \frac{453 \times 145 \text{ acres} \times 0.86 \text{ in.}}{22 \text{ hrs/day} \times 2.0 \text{ days/irrigation}}$$

$$Q_R = 1{,}284 \text{ gpm}$$

The manufacturer used 1,300 gpm for the design of the system.

Step 5. The manufacturer provides the data for Item No. 8. This must meet the criteria previously discussed.

a. Pivot length = 1,360 ft(outside tower = 1330 ft); pivot inlet pressure = 65 psi.

b. Impact sprinklers.

c. Gross application per revolution is 0.86 in. per 44 hours.

d. Nozzle gpm and pressure along last 100 ft of span is 10.1 gpm at 45 psi on spacing of 6.4 ft.

e. Nozzle wetted diameter is 102 feet.

f. Gun coverage = _____ ft; _____ gpm @ ____ psi (Not applicable to this problem)

Step 6. Check the maximum application rate, Item 9.

a. Time per revolution to apply gross application = 44 hrs (from manufacturer).

b. Velocity of outside tower:

$$v, \text{ ft/hr} = \frac{\text{outside circumference, ft}}{\text{hours per revolution}}$$

$$= \frac{(2)\ (3.14)\ (1330)}{44 \text{ hours}} = 190 \text{ ft/hr}$$

c. Determine time of application (i.e., time it takes the sprinkler to move past one point), average, and maximum application rates using the formulas provided in item 9.

Step 7. Complete Item 10. for sizing the mainline, determining total dynamic head and the net positive suction head required for the pump.

a. The mainline is 30 feet of 10-inch diameter PVC pipe (SDR 21). The friction head loss is 0.88 ft/100 ft and is taken from Appendix C. The total head loss in the mainlin is 0.88 ft/100 ft x 30 ft = 0.3 ft. The recommended maximum working pressure in the pipe is 0.72 x 200 (class rating)= 144 psi since it is assumed special means to control surge and water hammer will not be provided. The actual working pressure will be computed later in the problem.

b. The pressure at the pivot was given by the manufacturer and is 65 psi. The elev. increase from pivot inlet to highest sprinkler at high point along the lateral = 15 ft. or 6.5 psi. Therefore, the recommended pressure at pivot inlet = 65 + 6.5/2 = 68.2 psi.

c. The miscellaneous and fitting losses were estimated to be 3.0 psi.

d. The elevation difference from well to the pivot inlet was measured to be 12.0 feet.

e. The sum of a., b., c. and d. gives a pump discharge pressure at the main inlet pipe required of 176.7 ft or 76.5 psi. Enter this value also as the actual maximum working pressure in the main. The working pressure is less than the recommended maximum thus the pipe should be adequate.

f. The elevation pumping lift (from item 3) is 150 ft. Total lift including pump column and other losses would be slightly more. Use 150 ft as approximation for lift plus losses.

g. The total dynamic head is the pumping lift plus the pump discharge pressure, 150.0 ft + 176.7 ft = 326.7 ft or 141.4 psi.

h. The minimum net positive suction head available (NPSHA) is approximately equal to 31.0 - h_f + z. (see example in section 10-A for definition of values and Chapter 6 of this guide).
h_f = (use 3 ft for loss at impeller and in the well pipe)
z = 180-150 = 30 ft.

Therefore, NPSHA $\cong$ 31.0-3.0 + 30. = 58.0 ft

Step 8. Complete item 11, Pump Requirement. This is the maximum gpm the pump must produce at a given TDH. From Item 7, the actual Q for the irrigation unit is 1300 gpm. The TDH from the preceeding section is 141 psi or 327 ft. The NPSH required must be less than 58.0 ft (usually this value is most critical for centrifugal pumps).

Step 9. Complete item 12, Power Requirement, using formula given.

Step 10. Complete the plans. The specifications, location of the pipe, check valve, air vents, pressure relief valves, etc., should be shown on the plans.

CONSTRUCTION REQUIREMENTS

Once a system is designed it must be installed as planned in order for it to function properly. The following is a list of key points that should be checked during construction to be assured of a quality installation:

a. Depth of cover over the buried mainline is important for protection from vehicular traffic and farming operation.

b. Thrust block dimension and location to prevent pipe joint separation.

c. Location and size of air vents and pressure relief valve.

d. Size and proper direction of installed check valve.

e. Riser material and dimension as well as location for pivots.

f. Length and quality of pipe, diameter, location, appropriate ASTM designation, size, pressure rating and SDR as measured or found written on the pipe.

g. Determine if IPS or PIP pipe is used which will have an effect on the total head loss of the system.

h. Verify length of the center pivot lateral and if spray or impact type sprinklers.

LAYOUT CONSIDERATIONS

During planning and layout of a center pivot there are many things to be considered. Items to be considered are the soil limitations, obstacles such as fences, ponds, ditches and trees, topography of the field, the farming operation and safety hazards such as electrical and buried gas lines.

The soil limitations might affect the pivot's ability to traverse the field and/or the runoff erosion potential from high application rates.

Obstacles, if not considered, could result in severe damage to the pivot. Bridges or culvert crossings may be needed to cross wet areas or ditches. Electrical lines and buried cable or gas lines must be located prior to burying the pipe or locating the pivot, not only to facilitate installation, but to prevent a real safety hazard.

Topography must be considered because center pivots are limited as to the slope on which they can function properly.

The greater the land slope the greater the erosion potential. Therefore, the application rate must be compatible with the slope to prevent erosion from center pivot systems.

Procedure

For

Determining Gross Application of Center-Pivot Sprinkler

Objective

To develop a table that relates the dial setting of the center-pivot timer to the gross water (in inches) applied. The table may be used by the irrigator to adjust the system speed to obtain a desired gross application. The procedure described applies to electric system timers which read from 0 to 100 percent. However, the procedure can be adapted to other timers.

Procedure

1. Determine Speed of End Tower

   Select a reference mark on a wheel on the end tower. Set a stake by this mark. Start timing when the wheel starts moving forward. Continue timing until the wheel has moved 20 to 30 feet or until after the can catch is made. Mark distance traveled by placing a second stake by reference mark on wheel ans stop timing just as the wheel starts to move forward. Read time and measure distance between the two stakes.

   $$\text{Speed of end tower, ft per hr} = \frac{\text{Distance traveled, ft} \times 60}{\text{Time, min}}$$

2. Determine Time Per Revolution

   Once speed is determined, compute time of travel for one revolution at the % setting on the timer.

   $$\text{Time per revolution, hrs (At \% setting on timer)} = \frac{\text{Distance traveled by end tower, ft}}{\text{Speed of end tower, ft per hr}}$$

   Distance traveled by end tower, ft =
   2 x 3.14 x Distance from pivot to end tower, ft

3. Determine Hours Per Revolution For 100% Dial Setting

   $$\text{Hours per revolution (at 100\%)} = \frac{(\text{Hours per revolution})(\text{Dial Setting})}{100}$$

   Note: Use the dial setting on the control panel at the time the speed was determined and hours per revolution corresponding to this setting.

4. Determine Hours Per Revolution For Each Dial Setting

   $$\text{Hours per revolution at X\%} = \frac{(\text{Hours per revolution at 100\%})\ 100}{X\%}$$

5. Determine Gross Application For Each Dial Setting

$$\text{Gross application, in.} = \frac{(\text{Hours per revolution for dial setting})(\text{GPM})}{(453)\ (\text{Acres irrigated})}$$

Note: For acres irrigated, use design acres. If not available, use the effective wetted area.

Example

The center-pivot timer was set on 35% and end tower traveled 60.2 feet in 19 minutes. Distance from pivot to end tower is 1330 feet. System applies 1300 gpm on 145 acres.

$$\text{End tower speed} = \frac{(60.2)(60)}{19} = 190 \text{ ft per hr}$$

$$\text{Time per revolution at 35\%} = \frac{(2)(3.14\ )(1330)}{190} = 44 \text{ hrs}$$

$$\text{Hours per revolution at 100\%} = \frac{(44)(35\%)}{100} = 15.4 \text{ hrs}$$

Hours per revolution for each of the other dial settings:

$$\text{For 90\%} = \frac{(15.4)(100)}{90} = 17.1 \text{ hrs}$$

$$\text{For 80\%} = \frac{(15.4)(100)}{80} = 19.2 \text{ hrs}$$

$$\text{For 70\%} = \frac{(15.4)(100)}{70} = 22.4 \text{ hrs}$$

$$\text{For 60\%} = \frac{(15.4)(100)}{60} = 25.7 \text{ hrs}$$

$$\text{For 50\%} = \frac{(15.4)(100)}{50} = 30.8 \text{ hrs}$$

$$\text{For 40\%} = \frac{(15.4)(100)}{40} = 38.5 \text{ hrs}$$

$$\text{For 30\%} = \frac{(15.4)(100)}{30} = 51.3 \text{ hrs}$$

$$\text{For 20\%} = \frac{(15.4)(100)}{20} = 77.0 \text{ hrs}$$

For 10% = $\frac{(15.4)(100)}{10}$ = 154.0 hrs

Gross application for each dial setting:

For 100% = $\frac{(15.4)(1300)}{453\ (145)}$ = 0.30 in.

For 90% = $\frac{(17.1)(1300)}{453\ (145)}$ = 0.34 in.

For 80% = $\frac{(19.2)(1300)}{453\ (145)}$ = 0.38 in.

For 70% = $\frac{(22.0)(1300)}{453\ (145)}$ = 0.44 in.

For 60% = $\frac{(25.7)(1300)}{453\ (145)}$ = 0.51 in.

For 50% = $\frac{(30.8)(1300)}{453\ (145)}$ = 0.61 in.

For 40% = $\frac{(38.5)(1300)}{453\ (145)}$ = 0.76 in.

For 30% = $\frac{(51.3)(1300)}{453\ (145)}$ = 1.02 in.

For 20% = $\frac{(77.0)(1300)}{453\ (145)}$ = 1.52 in.

For 10% = $\frac{(154.00)(1300)}{453\ (145)}$ = 3.05 in.

Summary

Dial Setting	Hour/ Revolution	Gross Application - Inches
100	15.4	0.30
90	17.1	.34
80	19.2	.38
70	22.0	.44
60	25.7	.51
50	30.8	.61
40	38.5	.76
30	51.3	1.02
20	77.0	1.52
10	154.0	3.05

IRRIGATION DATA SHEET

System type (circle): (Center Pivot,) Traveling Gun, _____

(Other, list)

CONSERVATION DISTRICT Orangeburg FIELD OFFICE Orangeburg
COOPERATOR Bill Jones LOCATION Orangeburg Co
IDENTIFICATION NO. System 1 FIELD NO. 3

1. Design area 145 acres (Area actually irrigated)
Soil series Fuquay

Design Soil Series: Fuquay Predominate maximum slope 5 %

Soil Depth (in.)	Texture (USDA)	Average AWC (in./in.)
0-24	Sand	0.05

2. Crops:

Crop	Acres	Planting Date	Maturity Date
Corn	145	3/20	7/8
Total	145		

3. Water supply:
Source of supply: (stream, (well,) reservoir, etc.) 16 inch

Stream: Measured flow (season of peak use) _____ gpm

Reservoir: Storage ____ ac. ft. Available for irrigation _____ ac. ft.

Stream or Reservoir: Maximum drawdown available _____ ft.; Maximum elevation lift on intake side of pump _____ ft.

Well: Static Water Level 140
Measured Capacity 1450 gpm @ 10 ft drawdown
Design Pumping Lift 150 ft (to ground level - main pipeline inlet)
Pump Impeller Level 180

Distance supply source (main pipeline inlet) to field 0 ft

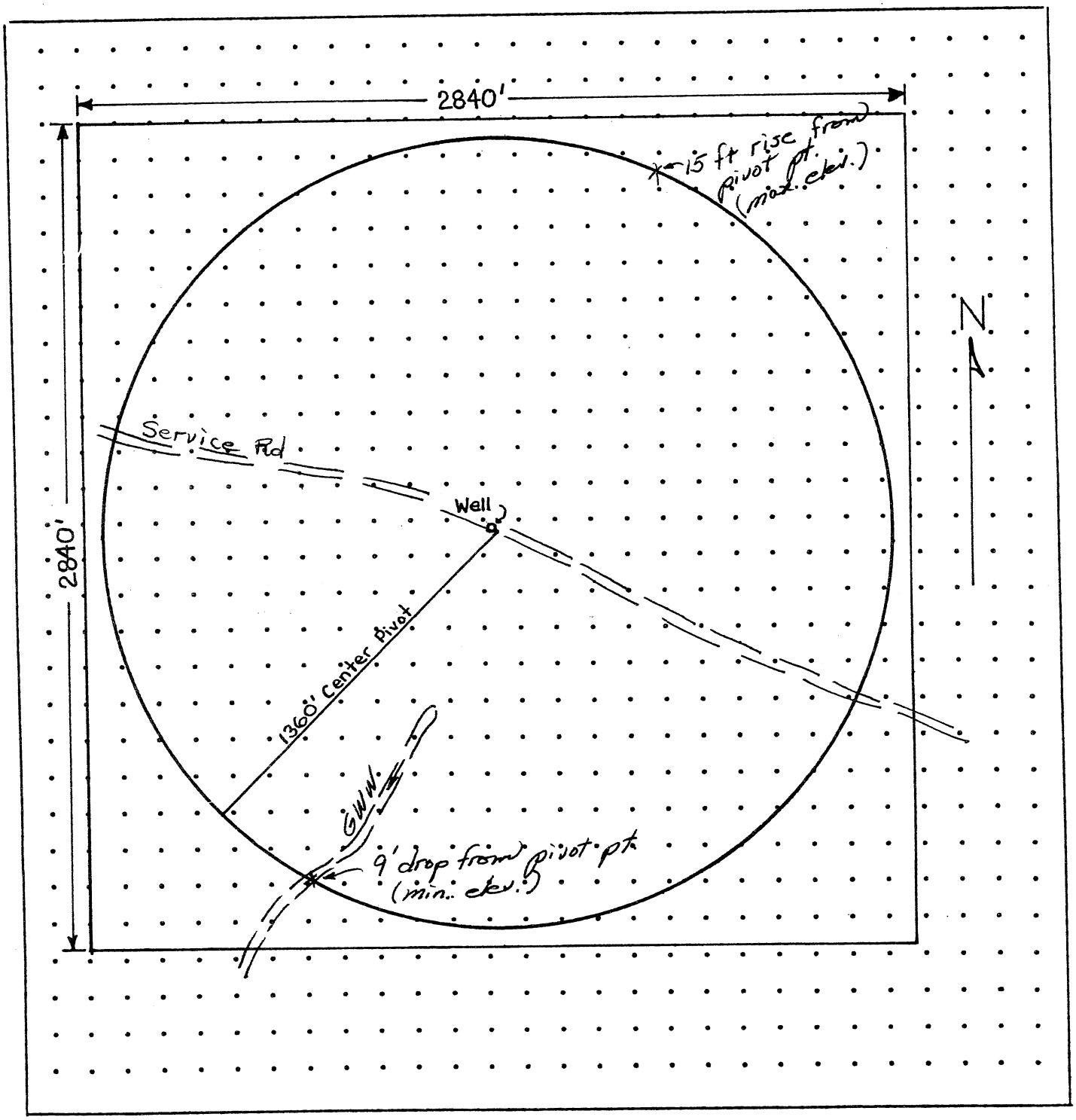
Quality of water (evidence of suitability): No apparent problems

4. Other Data:
Type of power unit and pump to be used: Diesel

CENTER PIVOT IRRIGATION SYSTEM Sheet 2 of 4

Cooperator: Bill Jones Designed by: Bob Smith Checked by: J. Stone

5. Map of design area - Scale 1" = 500 ft
Sketch map on grid or attach photo or overlay.



Sketch map should show:

a. Source of water
b. Major elevation differences
c. Row direction
d. Sprinkler system layout
e. Plan of operation
f. Field obstructions (gullies, trees, buildings, etc.)
g. North arrow

CENTER PIVOT IRRIGATION SYSTEM

Cooperator: Bill Jones Designed by: B. Smith Checked by: J. Stone

6. Crop and Soil Information	CROP NUMBER 1	2	3	4
Kind of crop	Corn			
Acreage to be irrigated (acres)	145			
Depth of Soil Water Control Zone	24			
Design peak use rate (in./day)	.30			
Weighted AWC for water control zone(in./in)	.05			

7. Design Procedure				
AWC within water control zone (in.)	1.2			
Depletion allowed prior to irrigation (%)	50			
Max. net water allowed per irrigation (in.)	0.6			
Net water applied per irrigation (in.)	0.6			
Max. recommended application rate (in./hr.)	No limit			
System efficiency (%)	70			
Gross application per irrigation (in.) 1/	.86			
Peak irrigation interval (days)	2.0			
Irrigation period (days per irrig.) 1/	2.0			
Hours operating per day 1/	22			
Q_R = Quantity of water required (gpm) 1/	1284			
Q_A = Quantity of water actual (gpm) 2/	1300			

8. Pivot Specifications: 3/
   a. Pivot Length 1360 ft(outside tower 1330 ft); Pivot Inlet Pressure 65 psi (Nominal pressure assuming level topography)
   b. Spray__ or Sprinkler✓
   c. Gross application per revolution 0.86 in. per 44 hours.
   d. Nozzle gpm along last 100' of span 10.1 gpm @ 45 psi on spacing of 6.4 ft
   e. Nozzle wetted diameter 102 ft; trajectory-low, (medium), or high (circle).
   f. End gun wetted diam. ___ft; _____gpm; _____psi; Nozzle size _____inch-ring or taper (circle); Trajectory-low, medium or high (circle)___degrees.

9. Checking Maximum Application Rate:
   a. Time (hrs) per revolution to apply gross application = 44 hrs
   b. Vel.(V) of end of line = $\frac{\text{outside circum. } 2\pi\ 1330 \text{ ft}}{44 \text{ hrs/revolution}}$ = 190 ft/hr
   c. Time of application (hrs) = $\frac{\text{wetted dia. ft}}{\text{V, ft/hr}} = \frac{102}{190} = 0.54$ hr
   d. Average application rate, in./hr = $\frac{\text{gross application, in.}}{\text{time of applic., hrs}} = \frac{.86}{.54} = 1.6$ in/hr.
   e. Max. application rate ≅ 1.3 x av. applic. rate = 1.3x 1.6 in./hr = 2.1 in./hr

1/ $Q_R = \frac{453 \times 145 \text{ acres} \times 0.86 \text{ inches gross application}}{22 \text{ hrs opr. per day} \times 2 \text{ days per irrig.}} = 1284$ gpm

2/ Q_A must be $\geq Q_R$

3/ Final specifications to be provided by manufacturer

CENTER PIVOT IRRIGATION SYSTEM

Cooperator:_____ Designed by:_____ Checked by:_____

10. Determining Total Dynamic Head:

Total main line length_____ft

Kind of Pipe and SDR, Sch, Class,etc	Pipe Size (in.)	Design Capacity (gpm)	IPS:__ PIP:__ PIPE SIZING		Total Head Loss		Working Pressure	
			Length (ft)	Friction Head Loss4/ (ft/100 ft)	(ft)	(psi)	Recommended Max. 5/ (psi)	Actual Max. (psi)
Needed at Pivot Inlet 6/								
Misc. & fitting losses (usually 3 psi +)								
Elevation Difference 7/								
Pump Discharge Pressure (main pipeline inlet)								
Pumping lift (including losses)								
Total Dynamic Head, TDH								
Estimated Net Positive Suction Head Available, NPSHA								

11. Pump Requirements:

Capacity _____ gpm @ _____ psi or _____ ft of head and NPSH less than ____ft.

12. Power Requirements:

$$BHP \geq \frac{\text{_____ gpm x _____ ft. TDH}}{\text{3960 x _____ pump eff. x _____ drive eff.}} = \text{_____}$$

4/ Keep velocity ≤5 fps unless means to limit surging and water hammer are otherwise adequate.

5/ For plastic pipe, 72 percent of the pressure rating unless means to limit surging and water hammer are otherwise adequate.

6/ Mfg. recommended pivot pressure plus one-half the elevation difference (plus or minus) from pivot inlet to highest point crossed by lateral in the field.

7/ Difference in elevation either from well or pump discharge (centrifugal pump) and the elevation of the pivot inlet.

Design Approved By:_____ Date:_____

SOUTH CAROLINA IRRIGATION GUIDE

CHAPTER 10-D. TRICKLE IRRIGATION SYSTEM

GENERAL

The example problem in this chapter is intended to illustrate the procedure to follow in the design of trickle irrigation systems. It is understood that one example cannot illustrate all design situations, site conditions or alternatives to consider when designing a trickle irrigation system.

DESIGN CRITERIA

Design criteria for trickle irrigation systems are contained in the Technical Guide, Irrigation System, Drip, Standard 441. All trickle irrigation systems must be designed in accordance with the criteria contained in Standard 441. Detailed guidelines for design of trickle irrigation system are given in NEH 15, Chapter 7.

EXAMPLE PROBLEM

The following example problem is intended to cover the basic design steps to follow in the design of trickle irrigation systems. A standard form (Exhibit 10-A-1) is used and is a useful tool in designing and in recording data.

Given:

1. Location: Aiken County.

2. Field Shape: 2,640 feet north to south and 1,320 feet east to west (80 acres).

3. Soil: Faceville S.L.

4. Crop: Pecans.

5. Row direction and spacing: north and south.

6. Tree spacing: 50 ft. x 50 ft.

7. Well information: existing 6 in. diameter.

8. Owner would like to operate half the system at one time. Emitter discharge rate preferred is 2 gph.

Solution:

The item numbers mentioned in the step by step solution refer to the items on the standard form "Irrigation Data Sheet" in Exhibit 10-D-1.

Step 1. Complete Items 1-4. These items provide pertinent data of the site.

Step 2. Complete Item 5. Make a drawing to scale of the field locating trees, well, and other features.

Step 3. Complete Item 6. The moisture extraction depth (soil water control zone) for the soil is 24 inches (Table 3-1). The design peak use rate 0.13 inches/day is taken from Chapter 4, Table 4-1 and is denoted by F_n. Note that F_n varies depending upon the value F (see step 5-C following) for orchards.

Step 4. Complete Item 7. The weighted AWC can be computed from item 1 and the permeability rate can be obtained from section II of the Technical Guide or from the county soil survey.

Step 5. Design procedure. Complete the following parts of Item 8.

a. Determine the field area "A" (ft^2 served by "N" emitters). This is determined by the tree spacing which is 50 feet x 50 feet which equals 2,500 ft^2.

b. Determine the design area of the crop for "N" emitters. The design area may be less than 100 percent of the field area but not less than the mature crop root zone area. The mature crop root zone area for the pecans in this example was determined to be .70 x 2500 = 1750 ft^2.

c. The value "F" which is the percent of "A" used for the design area, was determined to be 0.70.

d. Enter the water application efficiency. It is estimated to be 0.90 in this example.

e. Determine the number of emitters for the design area. A rule of thumb is wet a minimum of 25% of the root zone area. In this example, the minimum wetted area recommended would be 0.25 x 1,750 ft^2 = 438 ft^2. The wetted area from one emitter is estimated to be about 12 ft in diameter or about 113 sq ft. Thus the minimum number of emitters based upon area wetted = 438/113 = 3.9. The minimum number of emitters based upon capacity for 12 hours of pumping = (2471/0.9) ÷ [(2x12) x 17.4]= 6.6. Use 8 emitters per tree to allow uniform spacing of emitters along two laterals serving each row of trees (4 emitters per lateral).

f. The preferred discharge rate of emitters, Q, was given as 2 gph.

g. Determine the hours of operation per day, T.

$$T = \frac{F_n AF}{1.604QNE} = \frac{(0.13)\ (2,500)\ (0.70)}{(1.604)(2.0)(8)(0.90)} = 9.8 \text{ hours/day}$$

h. Determine the system capacity. There are 676 trees to be irrigated at one time with eight 2 gph emitters per tree. Therefore, the system capacity is:

$$\frac{676 \text{ trees} \times 8 \text{ emitters} \times 2 \text{ gph emitters}}{60 \text{ min/hr}} = 180 \text{ gpm}$$

Step 6. Complete Item 9. Select an emitter that will provide a flow rate of 2.0 gph. When selecting an emitter, a flow chart for the emitter should be obtained. Lateral lines normally are so designed that when operating at design pressure the discharge rate of any emitter served by the lateral will not exceed a variation of ± 10 percent of the design discharge rate (Technical Guide Standard 441-minimum variation = 15%).

The flow chart for the emitter selected in this example (2 gph @ 15 psi) has flow rate variations and corresponding pressure variations as follows (see similar flow chart for a 1.0 gph emitter in Chapter 5, Figure 5-6):

2.0 gph + 10% = 2.2 gph @ 17.5 psi
2.0 gph - 10% = 1.8 gph @ 12.5 psi

This allowable variation can be entered in the appropriate part of Item 11.

Step 7. Complete Item 10. The procedure for determining total dynamic head and net positive suction head available is similar to that described for sprinkler irrigation in Chapter 10-A. The pipe sizing data sheet was used to compute the friction loss in this example. Friction loss tables are included in Appendix C. The topography was gently sloping so elevation differences were included in the calculations.

The design emitter pressure was determined in Step 6.

The filter selected should be based on water quality and manufacturer's recommendations. The pressure loss in this example was based on manufacturer's literature.

The NPSHA $\cong 31.0 - h_f + z \cong 31.0 - 3 + 20 = 48.0'$

Step 8. Complete Item 11, Pump Requirements. This is the maximum gpm the pump must produce at a given TDH. In this example the pump requirements are 180 gpm at 173.4 ft of head and NPSH less than 48 ft.

Step 9. Complete Item 12, Power Unit Requirement. Assume pump eff. and drive efficiency are 0.7 and 1.0 respectively.

Step 10. Complete Item 13. Compare the actual pressure variation to the allowable pressure variation. The pump discharge pressure was computed to be 23.1 psi. The pressure at the first emitter is 23.1 psi - 1.0 psi (misc. loss) - 5.0 psi (filter loss) - 0.1 psi (submain loss) = 17.0 psi. This is less than the maximum allowable of 17.5 psi. The pressure at the last emitter is

23.1 psi - 1.0 psi (misc. loss) - 5.0 psi (filter loss) - 3.3 psi (submain loss) - 0.8 psi (lateral loss) = 13.0 psi. This is greater than the minimum allowable of 12.5 psi.

Step 11. Complete the plans. Include as needed: a chlorinator, check valves, pressure regulators, pressure relief valves, combination air vacuum valves, flow meters, gate valves, etc.

MATERIAL AND CONSTRUCTION REQUIREMENTS

Construction shall be done to the lines and grades determined by the design and the equipment and materials shall be of type, size and quantities specified in the plans. The installing contractor will be responsible for the proper installation of the system.

Emitters shall be installed as recommended by the manufacturer. Trenches excavated for pipe placement shall have a straight alignment. The width of the trench at any point below the top of the pipe shall be no wider than is necessary to lay, join, and backfill the pipe and in no event be more than 18 inches wider than the diameter of pipe. The buried pipe shall have a settled minimum cover as specified in the appropriate technical guides. All joints and connections involved in the installation of the pipe shall be made in accordance with the pipe manufacturer's recommendations and shall be constructed to withstand the maximum design working pressure for the pipelines without leakage. The quality of the pipe placed underground shall equal or exceed the quality requirements specified in the appropriate Technical Guides. Pipe placed above ground shall be as recommended by the manufacturer.

The filter system shall be of such that flushing, cleaning or replacement can be performed as required without introducing contaminants or foreign particles into the system. All injectors, such as fertilizer injectors, shall be installed upstream of the filter system, except for injectors equipped with separate filters.

Pumps, power units and filters shall be set on a firm base and be placed in proper alignment. All pertinent safety codes and manufacturer's recommendations shall be met.

Once completed, the system shall be tested for operating pressures, strength, leakage and satisfactory operation. During the initial start up, the lateral lines shall be flushed to remove any sediment or foreign materials before placement of end plugs.

The installing contractor or material supplier shall furnish the owner with written certification that pipe installed below ground will comply with the applicable standards referred to in the Technical Guides. The owner shall also be furnished a written guarantee by the contractor protecting the owner against defective materials and workmanship over a period of not less than one year after completion of all work covered under the contract.

IRRIGATION DATA SHEET

System type (circle): Center Pivot, Traveling Gun, (Drip)

(Other, list)

CONSERVATION DISTRICT Aiken FIELD OFFICE Aiken
COOPERATOR Robert Smith LOCATION Aiken Co.
IDENTIFICATION NO. Units 1 & 2 FIELD NO. 1

1. Design area 80 acres (Area actually irrigated)
Soil series Faceville

Design Soil Series: Faceville Predominate maximum slope < 1 %

Soil Depth (in.)	Texture (USDA)	Average AWC (in./in.)
0-6	S. Loam	0.075
6-75	S. Clay	0.15

2. Crops:

Crop	Acres	Planting Date	Maturity Date
Pecans	80	—	—
Total	80		

3. Water supply:
Source of supply: (stream, well, reservoir, etc.) 6" Well

Stream: Measured flow (season of peak use) _____ gpm

Reservoir: Storage ____ ac. ft. Available for irrigation _____ ac. ft.

Stream or Reservoir: Maximum drawdown available _____ ft.; Maximum elevation lift on intake side of pump _____ ft.

Well: Static Water Level 100'
Measured Capacity 200 gpm @ 20 ft drawdown
Design Pumping Lift 120 ft (to ground level - main pipeline inlet)
Pump Impeller Level 140'

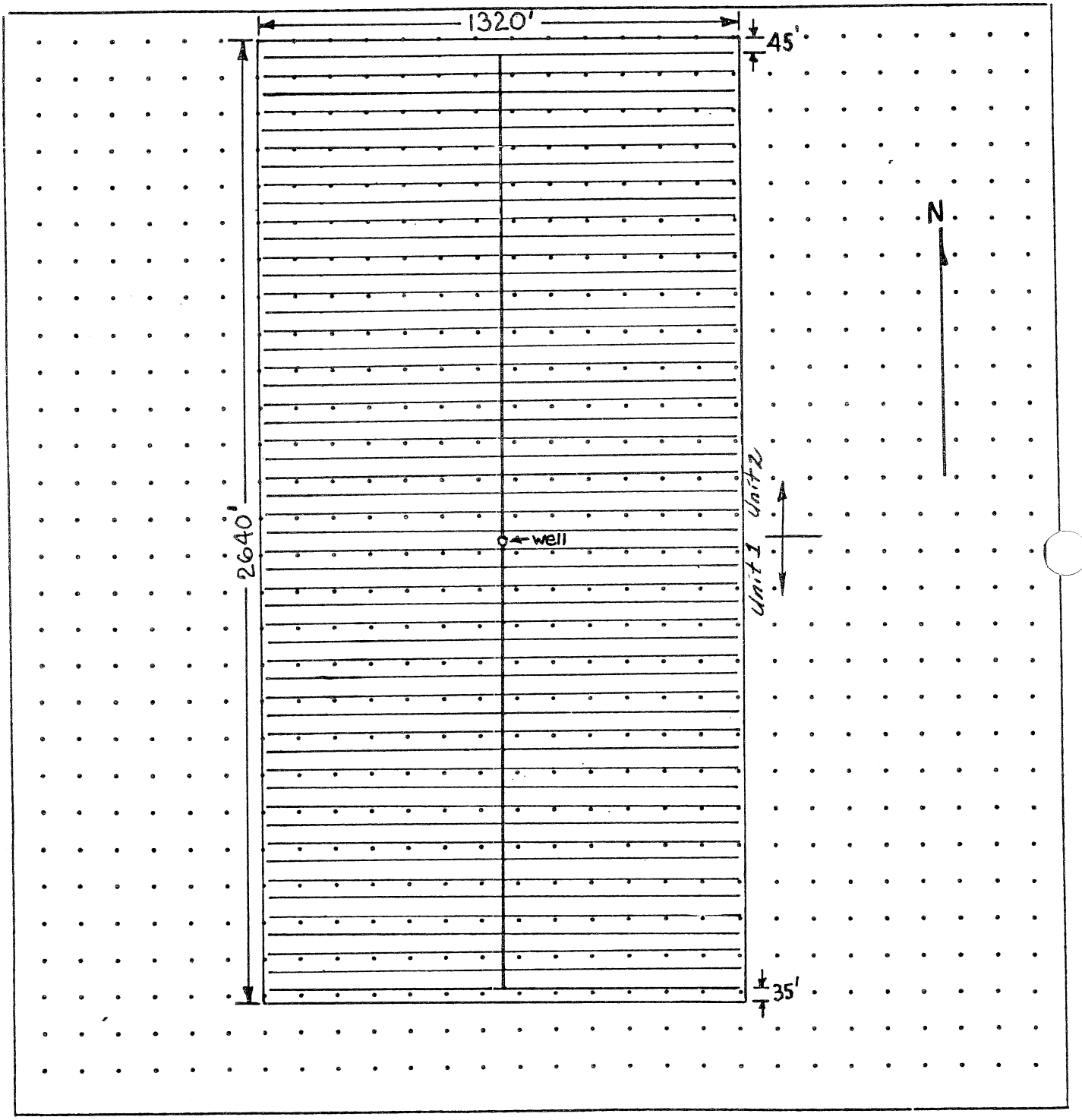
Distance supply source (main pipeline inlet) to field 0 ft

Quality of water (evidence of suitability): Good

4. Other Data:
Type of power unit and pump to be used: Electric - 3 Ph.

Cooperator: Robert Smith Designed by: J. Jones Checked by: J. Stone

5. Map of design area - Scale 1" = 400 ft
Sketch map on grid or attach photo or overlay.



Sketch map should show:

a. Source of water
b. Major elevation differences
c. Row direction
d. Sprinkler system layout
e. Plan of operation
f. Field obstructions (gullies, trees, buildings, etc.)
g. North arrow

TRICKLE IRRIGATION SYSTEM

Cooperator: R. Smith Designed by: J. Jones Checked by: J. Stone

6. Crop Information	IRRIGATION UNIT NUMBER 1	2	3	4
Kind of crop 1/	Pecan	Pecan		
Acreage to be grown (acres) 1/	40	40		
Soil Water Control Zone (in.)	24	24		
Peak use rate (in./day), F_n	.13	.13		
7. Soil Information				
Weighted AWC for rooting depth (in./in.)	0.13	0.13		
Permeability (in./hr)	0.6 - 2.0	0.6-2.0		
8. Design Procedure				
"A" field area served by N emitters (ft^2)	2500	2500		
Design area of crop for N emitters (ft^2)	1750	1750		
"F"-% of "A" used for design area(decimal)	0.70	0.70		
"E"- water application efficiency (decimal)	0.9	0.9		
"N"- number of emitters for design area	8	8		
"Q"- discharge rate of emitter (gph)	2	2		
"T"- hours of operation per day(18 hrs max) 2/	9.8	9.8		
System capacity (gpm) = ("N" per irrigation unit (52 emitters)(104 laterals)) X "Q"^{2} / 60	180	180		

9. System Specifications

a. Emitter spacing = 12.5 ft, lateral spacing 50 ft (dual laterals, each = 6' from tree row)

b. Emitter capacity 2 gph @ 15 psi

c. Max. length lateral 650 ft, size 3/4 in., Number of emitters 52

d. Total number laterals 208 ; Number operating simultaneously 104 ;

e. Total number of emitters 10816

1/ For orchards, list tree spacing and canopy area.

Tree spacing 50 ft by 50 ft

Canopy area 1750 ft^2 [assumed to be the root (design) area]

2/ Use the following formula:

$$T = \frac{F_n A F}{1.604\ Q N E}$$

TRICKLE IRRIGATION SYSTEM

Cooperator: R. Smith Designed by: J. Jones Checked by: J. Stone

10. Determining Total Dynamic Head 3/

Kind of Pipe			Design Capacity (gpm)	IPS PIP Other___ Diameter (in.)	Length (ft)	Friction Head Loss 4/ (ft/100ft)	Total Head Loss HL (ft)	Total Head Loss, HL		Working Pressure	
Main	Sub-Main	Lateral						(ft)	(psi)	Recommended Max 5/ (psi)	Actual Max. (psi)
XXXX		✓	(see sh. 5 of 5)					XXXX	XXXX	57.6	17.1
XXXX	✓							XXXX	XXXX	115.	23.1
XXXX								XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX								XXXX	XXXX		
XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	XXXX	9.62 x 0.5 = 4.8 6/	2.1			
→	XXXX	XXXX					XXXX	0	0		
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
	XXXX	XXXX					XXXX				
Design Emitter Pressure								34.6	15.0		
Friction Loss in filter System								11.6	5.0		
Miscellaneous Losses								2.3	1.0		
Pump Discharge Pressure (at entrance to submain)								53.4	23.1		
Pumping Lift (including losses)								120.	51.9		
Total Dynamic Head, TDH								173.4	75.0		
Estimated Net Positive Suction Head Available, NPSHA								48'	—		

11. Pump Requirements: 180 gpm @ 75.0 psi or 173 ft of head and NPSH less than 48 ft.

12. Power Unit Requirement:

BHP ≥ $\frac{180 \text{ gpm} \times 173 \text{ ft TDH}}{3960 \times 0.7 \text{ pump eff.} \times 1.0 \text{ drive eff.}} = 11.2$

13. Check allowable pressure variation that will provide a ± 10% flow rate
Allowable = 12.5 psi to 17.5 psi (Taken from manufacturer's curve)
7/ Actual = 13.0 psi to 17.0 psi

14. Remarks

3/ Use pipe sizing data sheets where elevation differences are present and/or additional data lines needed.
4/ Keep velocity ≤ 5fps unless means to control surge and water hammer are otherwise adequate.
5/ For plastic pipe, pressure rating divided by 0.72 unless means to control surge and water hammer are otherwise adequate.
6/ Sets optimum nozzle pressure at a theoretical mid-system sprinkler.
7/ Consider elevations and location. Adjust 6/ if possible to stay within allowed variation. If not, the system must be redesigned.

Design approved by: _____ Date: _____

PIPE SIZING DATA SHEET

Cooperator R. Smith
Field Office Aiken

Sheet 5 of 5
Designed by J. Jones
Checked by J. Stone

Irrigation Unit No. 1			Pipe Sizing Calculations								Pipe Material ___, SDR ___ IPS ✓ PIP ___ Other ___
Main	Sub-Main	Lateral	Design Capacity (gpm)	Pipe Diam. (in.)	Length (ft)	HL_f (ft/100')	Multiple Outlet Factor	Total HL_f (ft)	Elevation Difference HL_e (ft)	Total HL HL_f+HL_e (ft)	REMARKS
		✓	1.73	3/4	650	0.37	.361 [1]	0.87	1.0	1.87	PE Pipe, SDR 17, Class 80
	✓		180.	5	1300 [4]	0.50	.356 [2]	(+2.31	1.5	3.00	} PVC, SDR 26, Class 160
	✓		125.	5	900 [5]	0.25	.358 [3]	-0.81)			
	✓		125.	4	900	0.73	.358 [3]	2.35	2.4	4.75	
										Σ 9.62	

[1] 52 outlets
[2] 104 "
[3] 72 "
[4] Actual length of 5" dia. = 400'
[5] This length entered for computations only.